



SAVONIA
UNIVERSITY OF APPLIED SCIENCES

Study and Optimization of Automatic Box Making Machine

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Bachelor's Thesis

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Field of Study Technology, Communications and Transport.			
Degree Programme Degree Programme in Industrial Management			
Author(s) Md. Ashraf Ul Alam			
Title of Thesis Study and Optimization of Automatic Box Making Machine			
Date	10.08.2014	Pages/Appendices	40
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Client Organisation/Partners Savonia University of Applied Science, Varkaus, Finland/Famifarm oy			
Abstract <p>Optimizing helps business to run like a well-oiled machine. Efficiency in operations directly translates positively in the company's bottom line. The need for ever-changing process innovations is persistently fuelled by rapid technology advancements and demands on organizations to improve their bottom-line. Installation of new machine or hiring more people doesn't help the improvement always, but to align and streamlining the resources together is also very important.</p> <p>The research area belongs to manufacturing processes development and topic is study and optimization of automatic packaging machine. Primary objective of this research is to study and find the development areas in the flow production department of the case company, to find out performance boosters and suggest implementation process for the changes. Secondary objective is to provide the improved structure of flow production department in the greenhouse sector.</p> <p>In a nutshell, the research was a successful project for me and for Famifarm Oy. The company has decided to do some of the modifications to the machine as I suggested. The modification will help the company to achieve their targeted benefit.</p>			
Keywords Automatic Box Making Machine, Packaging Machine, Machine Improvement, Efficiency			

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Definition of Terms and Abbreviations

Automation

Automation is the use of some kind of controlling systems and technological equipment to decrease the amount of human work and labor in the industrialization, automation works like an important role player for mechanization. [1]

Efficiency

Efficiency can be described as a diameter to calculate time or effort for a task. It also explains the accurate outcome of a purpose. [2]

Packaging

It is a procedure for the enclosure of goods for different purposes such as product delivery, product storage and product sale. [3]

Die

Die is a special kind of tool or element that is specially used for manufacturing process. Mostly A Die is pressed by mold and is shaped for the desired product.

Mold

A mold is a hollow container that is used to shape up Die materials.

Cardboard

A substance that is made of stiffed paper. In this research study the Die element is Cardboard.

ABMM Automatic-Box-Making-Machine

RHS Right hand side

LHS Left hand side

1 INTRODUCTION

The automation concept has changed the output service and products in factories since the industrialization time period in developing countries. Upgrading the automation systems in automated machines and control systems changes the industrialization vision. With advanced technology, engineers always try to develop, invent and improve the machines, which will make the work more efficient.

1.1 Research Background

Now a day it is not only enough only to stay and survive in the competition of industrialization but also to go ahead and try to be the best. In today's business market a company has to face extreme challenge on customer satisfaction, product quality, product revenue. To become the best in their own field, companies are now investing on new technologies, which can give a big amount of profit after certain time.

Famifarm Oy is one of the best and fastest growing companies in green house business area. The demand of some of their products is increasing day by day. For the customer demand and for the benefit of the company they are always in search of quality improvements as well as quality.

This research is focusing on the development policy of the company. The automatic box making machine or an automatic machine for Assembling Cardboard cases is one of the most demandable machines, which is connected to the Flow Packing Machine Unit. The production rate of a particular product is mostly dependable on the performance of that machine.

1.2 Objective of the study and research problems

The research study was started with the aim of searching for solutions for the improvement of the performance of the ABMM (automatic box making machine) in Famifarm On Joroinen. The research therefore has set the present performance and suggested the visible solutions for the improvement of the ABMM.

It is also planned that the research study will offer some advanced and new models for the industrial automation machines in Finland. It is included in the framework that the research will add findings on the packaging machine, which will help to moderate the vision of the Finnish society and other oriented society as well.

The research study is also initiated for the researchers interest toward s the automation technologies. The “Manufacturing Automation” lessons during the researcher’s Bachelor degree Programme have created a strong point of interest towards Automation.

Improving the efficiency and performance of ABMM was the main focus of the thesis. The main reason of the thesis was to check out the present performance of the ABMM and its efficiency, which is importantly needed for the increase of the productivity in Famifarm Oy. The performance of the ABMM has a important role in the production sector of Famifarm Oy and therefore it is needed to increase the production rate.

The author’s discussion with the manufacturer of ABMM and analysing the original performance rate arises some research problems.

1. The machine is originally designed for making 2400 pcs/h (40pcs/min) while the machine is working in its highest capacity. Nowadays it is making about 1300 pcs/h.
2. Other performance factors are the mechanical solutions which are used in the machine and which are chosen by the demand of product type and capacity.

The machine was first installed in 2008 in Famifarm Oy and at that time the machine parts were mechanically settled according to the demand of the production but day by day the demand increased but on the other hand the changes and improvement in the machine have not done with the same pace.

Rather than taking full output from ABMM, the company is not using even its half of the capacity because of having so many lacking as like as technical lacking, lacking of experts to use and to maintain the machine.

During the time of production the ABMM makes a significant number of errors.

1. The cardboard gets stacked several times during the production.
2. There is a problem of gluing the boxes.
3. The box also gets stacked several times.

1.3 Methodology and research tools

“Research is a process of expanding the boundaries of our ignorance”.
(Goddard and Melville 2007, 1)

Research methodology is the way to know what and how a researcher is going to do his/her research. It also helps the researcher to make a framework, which will help him/her to do the research according to the mainstream and research type.

From the very beginning till the end of the whole research program, research methodology helps the researcher to keep involved with the field of gathering information. Planning could be done on right track only by choosing the right methodology for the research.

In the research paper of Qualitative and of Quantitative both of the methods are used for data collection. Mainly qualitative method is followed by collecting data by doing face-to-face interviews with some of the technical experts of ABMM.

Making data collection sheet to observe the facts, which is affecting the production of the ABMM, follows quantitative method. Most of the observation is done by the self-participation in the production areas. It helps a lot to understand the actual problems and there symptoms. [8]

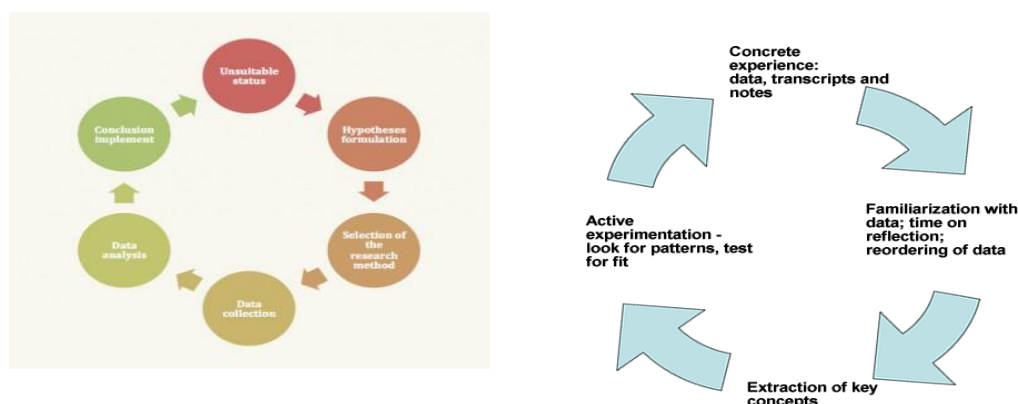


Figure 1. Qualitative research and Quantitative research, Google image search engine, 2014

2 Automatic Packaging systems in Famifarm Oy

In all sectors of packaging in Famifarm Oy the all of the systems are automated. Various kinds of automatic packaging machines are used for the purpose of packaging.

2.1 Famifarm Oy

Famifarm is one of the oldest manor house in Järvikylä and it is the market leading salad growing green house factory in Finland. The owner of the manor house is Grotenfelt family from the beginning. The family of Grotenfelt has a major influence on joroinen area from the 17th century. Famifarm Oy has two green houses. One of them is located in Joroinen and the other is located in Juva. The company also has contract grower Turakkala Oy and Viherkaste Oy. The factory that is situated in Joroinen is the biggest and planting and production set up by the company. Famifarm Oy produces vegetables and herbs in the green houses and t is packed in different packing system such as cut and boxed. The product brand is named after the name of the factory location area that is Järvikylä. These products have a wide range of customers including household consumer, retailers and HoReCa (Hotels, Restaurants and Catering). Most of the company products are sold in Finland and a small portion is exported to outside of Finland. [4]



Figure 2. Brand logo of Famifarm (järvikylä 2012)

There are about 110 people working (Production 84, Maintenance services 06, Management 10) in Joroinen greenhouse. In Juva there are 10 people in production and management. The Marketing Division is situated in Helsinki. The production capacity of the green house in Joroinen is summarized in Table 1.

Table 1 Summary of the production capacity in Joroinen

Total Area of Greenhouse	4.9 hectors
Number of production Houses	10
Number of production Lines	22
Number of Gutters (kourut)	16200
Plants	156030

The products grown at Turakkala Oy on a subcontract basis include a variety of herbs as Thai Basil, Kaneli Basil, Mint, Asian Mint, and Strong Mint. Oregano, Mariam, Coriander, Lemon leaves, Salvia, Rosemary, Sunflower, Basil tree, Napoli Mix, Spinach. Some of these products are also produced in bigger shape and bigger packs.

Figure 3 shows lettuces and herbs that are mostly produced in Famifarm Joroinen while partly by other growing partner. But at the end the products either grown in Joroinen or Juva factories are complied and dispatched from greenhouse dispatch center of Joroinen.



LETTUCES AND HERBS



Figure 3. Herbs grown under Järvikylä brand (Järvikylä 2012)

2.2 Packing machine

TECO is a company that is making machines for cardboard packaging. It was established on January 1995 and on result of the experiences gathered in the field of packaging machines thorough of years of productions. The Company is a sister company of CARTECO, which is famous for corrugated board packaging operating since 1989.

The company earned a reputation in the field of cardboard and fresh produces and turned into a major Italian manufacturer of automatic formers for corrugated board.

The production program offers tray formers for corrugated and solid board, American boxes, loading machines and plastic crates erecting machines.

TECO is a company that mainly produces solid and user friendly standard machines, but if a company demand according to their own needing then hey also provide customized machines. As a matter of fact, TECO has their own technical team and they are the owner of their all mechanical drawings, structural drawings of the machine and know-how.

The constant efforts on investment and generating new ideas for innovation TeCo has created its own image for the buyers. TeCo normally relies on business to business.[5]



Figure 4. TeCo official logo, www.tecoitaly.com (2014)

2.3 Description of the machine

This machine consists of so many different units and each part is connected to each other and responsive to each other.

2.3.1 Technical data

The machine now in use in Famifarm Oy, is T2S. But the most interesting point is that could easily converted to the other two models such as T2I and T2A. The reason to use T2S is it has the highest rate of production. Talking away some of the partly connected portions can convert the T2S to T2I or T2A machine.

Table 2. The table shows comparison and specification of the

Machine Data			
Name	Automatic machine for forming cardboard cases		
Model *	T2S		
Year of construction *	2009		
Serial number *			
General features	T2S	T2I	T2A
Machine name	Automatic machine for forming cardboard cases		
Length	3230 mm	3790	3330 mm
Height	2125 mm	2040	2125 mm
Width	1530 mm	1670	1530 mm
Approximate weight	12 q.li (max)	14 q.li (max)	13 q.li (max)

Table 3. The table shows other significant specifications of the machine

** Operating environment (common to all models)			
Operating temperature		+5÷+35 °C	
Storage temperature		+1÷+50 °C	
Ambient humidity		+10%÷95%	
Max. Altitude above sea level		1000m	
Noise		<80 dBA	
* Technical features	T2S	T2I	* T2A
Max. production capacity	2400 trays/hour	1700 trays/hour	2400 trays/hour
Case format 600x600	Height 60÷250 (1) mm	Height 60÷300 (2) mm	Height 60÷250 mm
Case format 300x200	Height 60÷250 (1) mm	Height 60÷300 (2) mm	Height 60÷250 mm

2.3.2 General Description

The Teco2s forming machine has been designed and built to assemble cardboard cases starting from pre-die-cut sheets of cardboard. This assembly is carried out by mechanical devices controlled by electro-pneumatic actuators with the aid of “Hot Melt” glue applied to particular points.

DIE-CUT ELEMENT: sheet of card with a particular shape, particular cut-outs and/or creases so that, when correctly folded, a specific geometrical shape is obtained (particularly cases). The unfinished item that feeds the **T2** shaper is a die-cut element.

CREASE: area of the die-cut element subject to the passage of a hard wheel, which alters the inner structure, enabling easy folding along the crease (e.g., sides and ends of cases).

PLATFORM, PLATEAUX, TRAYS: other names to indicate the cardboard case formed by the **T2** **DANGER AREA:** any area within or nearby the

machine where there is a risk to the health or safety of a person.

EXPOSED PERSON: any person inside a danger area

OPERATOR: person responsible for the installation, operation, cleaning, maintenance and handling of the machine.

USER: Qualified and trained operator, capable of carrying out the tasks necessary to operate the machine: implementation of the operator controls, interpretation of the signals, possible operations to free blockages, other simple operations linked to normal production, cleaning and daily inspection. The user operates only when the safety guards are operative.

MECHANIC: Qualified technician capable of running the machine, like the user, and also of making it work when the safety guards are not operative, intervening on mechanical organs to make adjustments and/or replacements, but not carrying out operations on the electrical system while the machine is connected to the power supply.

ELECTRICIAN: Qualified technician capable of running the machine, like the user, and also of making it work when the safety guards are not operative, intervening on electrical systems to carry out maintenance and/or repairs. The electrician also operates when the electrical panels, control equipment, etc., are electrified.

MANUFACTURER'S TECHNICIAN qualifies technicians operating for the manufacturer or his representative, who intervenes exclusively for complex repairs or special alterations, upon agreement between the parties.

RIGHT AND LEFT: the words right or left indicate the sides of the machine, moving parallel to the movement of the cases on the machine.

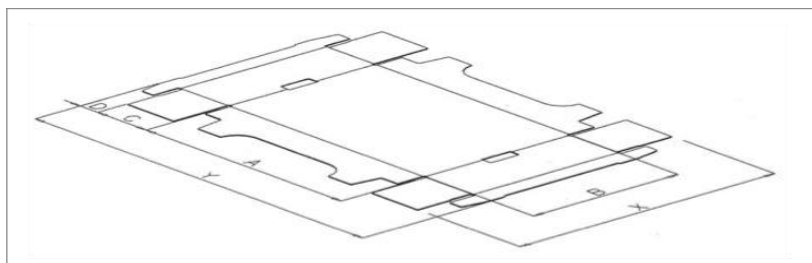


Figure 5.1 Max. And Min. assembling dimensions of Card Board

Table 4. Maximum and minimum dimensions of Card Board

Modell T2s	A	B	C	D	X	Y
Minimum	280	180	60	30	360	440
Maximum	610	610	250	70	1010	1220

2.4 Operation of ABMM

The operation of the forming machine can be summarized in the following phases:

- . Phase 1: loading die-cut elements in the store (carried out manually by the operators or using an optional automatic loader)
- . Phase 2: gripping the die-cut element (by the sucker arm)
- . Phase 3: transport from the store to the press (by conveyor and pusher)
- . Phase 4: glue distribution (by specific spray nozzles)
- . Phase 5: case forming (by press)
- . Phase 6: case expulsion (by movement of the press)
- . Phase 7: maneuvering the expelled tray (with extractor belt, distribution line, IM04 accessory, etc.)

Loading is the operation in which the sheets of pre die-cut cardboard are taken from the pallet and placed inside the cardboard store. It is an operation,

which is usually carried out by the forming machine operator before the forming machine pick-up arm has picked up the last sheet in the cardboard store. This prevents stoppages during the machine phase (caused, obviously, by the aforementioned lack of cardboard) and extended production times caused by machine stoppages.

By request, a semi-automatic loader can be installed on the machine.

We need to remember that the machine's maximum production speed is 2400 pieces/hour (this speed cannot be reached by all sizes produced: more complicated elements requiring more laborious gluing operations, such as folds, upper band, etc., implicate longer assembly times, so machine production falls). The sucker arm picks up a sheet every 1.5 seconds, so if we assume a load of 20 sheets of cardboard every time, this operation must be repeated at intervals of roughly 30 seconds. After the forming machine has been started, the pick up arm takes a die-cut element from the store and places it on the dragging conveyor. The sides of the die-cut element rest on special running guides and the introducer unit, once the die-cut element is rested on the guides, grips it by means of special contrasts alongside the guides. After depositing the die-cut element on the dragging conveyor, the latter begins moving and uses a special pusher connected to it, moves the die-cut element from position (1) under the store to position (2) under the press mold.

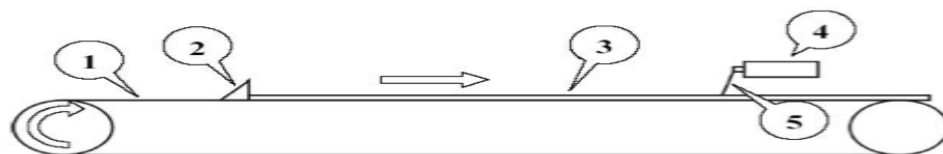


Figure 6. Diagram of lateral transport from position 1 to position 2

In the passage from the store to the pressing station, the die-cut element passes under 2 nozzle units, known as glue guns, which deliver hot melt glue following a set timing schedule which varies for every size of cardboard processed by the machine.

After the pusher has moved the die-cut element from the cardboard store to the forming station, made up of a press, a hopper (inside which the press pushes the die-cut element) and a series of mobile arms which form the various secondary flaps of the case (double folds, upper bands, etc.), it takes the shape of a finished case and is inside the forming hopper.



Figure 7. View of forming hopper with assembled die cut element

The case assembled inside the hopper is pushed under the aforementioned hopper when the next die-cut element is assembled. If there is no collection-extraction system, the case remains on the ground. There is usually an extractor belt to maneuver the cases as they leave the forming station.

2.5 Working Procedure

There are several major working procedures of the packing machine. Each of the procedure should be perfectly tuned to run the whole system smoothly.

2.5.1 Preliminary Adjustment

The machine can work with different types of case, with different formats and different sizes, so it is necessary to position the various devices implicated during the assembly of the case. The whole sequence of operations described in this chapter must be carried out every time the format to be produced is changed.

Before beginning any format change procedure, the machine must be completely free from any die- cut elements or cases remaining from the previous work cycle.

2.5.2 Type of case and format

The sequence of operations to be performed to equip the forming machine to work with a specific format depends on the type of case (with or without folded ends, with or without folded sides, with or without upper flaps), its size and the previous operating format, as the procedure for equipping the machine is different if a product passes from a large format to a smaller one with respect to switching from a smaller format to a larger one.

2.5.3 Functional units implicated in the assembly

18 functional units are connected to the hopper and these can be divided into 6 types, which depend on the type of cases to be assembled as follows.

1. Lateral Pressure unit (4 units)
2. Cardboard stop (2 units)
3. Flap closure units (4 units)
4. Flap pressing unit (4 units)
5. End folding and side folding units (2units and 2 units)

2.5.4 Format change adjustment procedure

After identifying the format of the case to be assembled and therefore the functional units implicated in the assembly, it is necessary to adjust the units. The procedure for equipping the machine is different if production passes from a large format to a smaller one with respect to switching from a smaller format to a larger one.

2.6 Comparison of principles and Theory of Automation with the Operation of ABMM

In the field of automation, early developments and automation have provided three building blocks of automation.

1. Power source to perform action
2. Feedback control
3. Programming of machine

Without any exception, an automated system will exhibit all these elements.
[Fig 8]



Figure 8. Steps starting from cutting then conveying and wrapping

The two main products that are packed throughout the flow production process are Ice lettuce and frisee lettuce. At first the product is picked up from the line and it travels through the conveyor belt to the packing room. After wrapping the product in flow packing machine the product is served into a moving packing table. Then it has been packed into the boxes made by ABMM.



Figure 9. Automatic Box Making Machine (front view)

The ABMM can produce now a days 1300 boxes per hour. In each box ice lettuce is packed in two different numbers and they are 12 pcs/box and 8pcs/box. Frisee lettuce is also packed in 12 pcs/box and 8 pcs/box as well. Each box is printed with the name of product category and packing date and amount of packets. In each boxes the date of packing is also printed. A printer that is manually assembled with ABMM by the permission of the manufacturer does the whole printing process.



Figure 10. Final Products in the storage.

After packing the products into boxes then each boxes are placed on a palate (FIN lava). Every palate consists of 50 boxes.

3 Performance and efficiency analysis

To understand the efficiency changes and several factors have been included for analysis. The standardisation of inputs and outputs are necessary because of the relationships between Price Factor and Consumer Demand in the fields of economy.[4]

In this part of study researcher identifies some of the problems that occurs regularly during the packaging process. By very careful and thorough observation researcher has found some serious issues that is prohibiting the ABMM to give the total output.

The measurement variables that are used for the analysis of performance and efficiency of ABMM are

- Machine efficiency
- Energy
- Quality
- Cost efficiency
- Staff know-how

Theory of automation is very important to the operation and performance of the packaging system. Most of the errors could be minimized by the minimizing the malfunctions and by setting the ABMM to its standard settings. The improvements have been done in AMBB in some of the sectors of ABMM.

3.1 SWOT analysis of manufacturing Engineering

SWOT analysis has been done on the manufacturing and automation field in Finland. The analysis shows the sectors which could be improved and which can take Finnish economy to a strong position. The engineers should work for the better sake of improvement in the field of performance and efficiency. Industrial growth is one of the important factors to make the economical condition strong for a country.

Separate tables show the Strengths, Weakness, Opportunities and Threats for manufacturing engineering.

Strengths

- Well infrastructure.
- Well public administration.
- Stable environment.
- Effective education system.
- Higher education opportunities.
- Labor force.
- Presence of basic skills.
- Specialization in study.
- Established culture.
- Strong worldwide companies.

Weaknesses

- Very High labor costs.
- Small markets.
- The situation is far from other growing markets.
- There is not enough students for higher studies.
- Not enough technical workers in some fields.
- Comprehensive energy of manufacturing.

Opportunities

- Improvement of productivity.
- Combination of new concepts and products.
- Availability of orientation of product orientation to market
- Design.
- Competing with the global markets via developing process.
- Environmental-friendly technologies and products.
- The opportunity of technology growth.
- Possibility of globalization of

Threats

- High costs of labor.
- High cost of services.
- High cost of materials and energy.
- Energy requirements for efficiency.
- Economical slow-down.
- Wrong selection of products.
- Overlooking some sectors that could be long lasting.
- Globalization.
- Worker shortage.

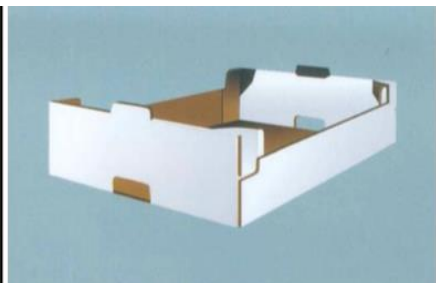
After SWOT analysis researcher came to end that the strengths and opportunities are so vast in Finnish industrial areas of development that the weaknesses and threats cannot have an alarming number of influence. In Finland there is a very suitable situation for nurturing the developments.

3.2 Card board analysis

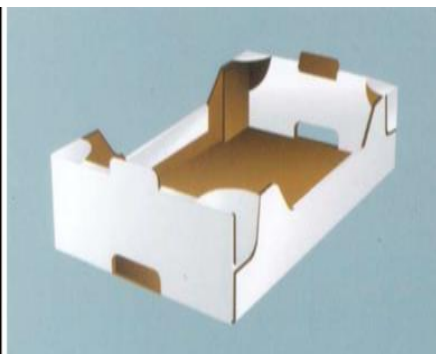
Generally as per as consumer demand the company is producing three different kinds of boxes. All kind of boxes types are shown in below by figures and functional units that are implicated are also described.



- Lateral Pressure
- Cardboard stop
- Flap closure
- Flap pressure



- Lateral Pressure
- Cardboard stop
- Flap closure
- Flap pressure
- Double ends



- Lateral Pressure
- Cardboard stop
- Flap closure
- Flap pressure
- Double ends
- Double ends

Figure 11. Different shapes of boxes

The type of box, which is generally produced in daily basis, is the first one. The standard size of the cardboard is described in Table 3. But there is also a correction factor. The correction measurements are given below.

Table 5. Correction measurements

Width	+2mm	720mm	722mm
Centering	0	180mm	180mm

3.3 Mechanism analysis

The suckers are positioned in line with the front end of the die-cut element, about 20-30mm above the bottom crease, as indicated in figure 12. When the screws are loosened and manually placed then the suckers are positioned. By sliding them along the arm after reaching the correct position then tighten the screws again (3).

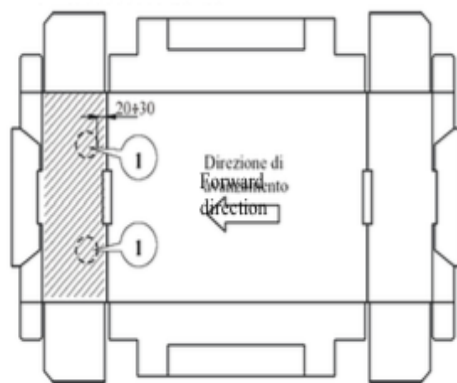


Figure 12. View of the die cut element with position of the imprints of the pick up suckers

Then it is needed to check that they are more or less in axis with the front container posts and yielders (4), positioned earlier, as indicated in Figure 13

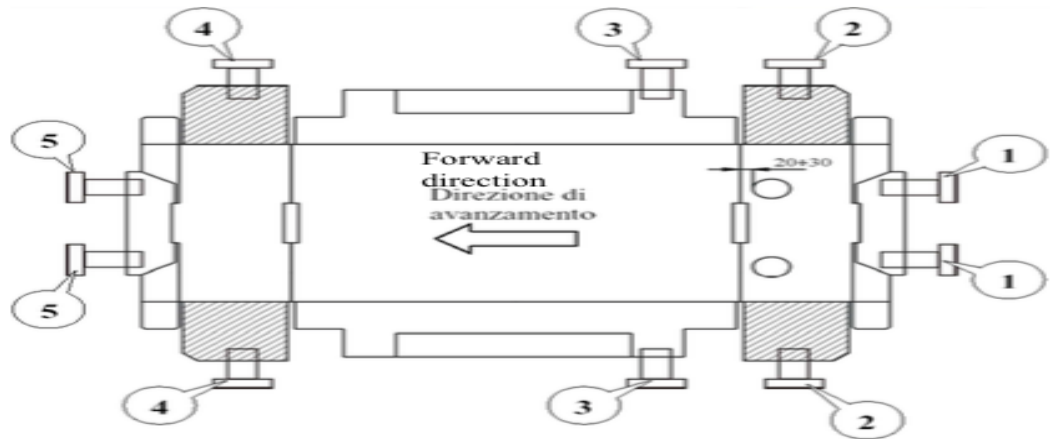


Figure 13. The position of yielders

After positioning the die-cut element under the forming hopper, it should be taken care care to rest it against the rear centering devices (1). We need to check that the crease between the box end and bottom on the cardboard store side (2) is vertically aligned with the fixed thread of the hopper according to the diagram indicated in Fig. 14.



Key

- 1) Rear centres
- 2) Crease between box and bottom
- 3) Die-cut element

Figure 14. Hooper threads

When the die-cut element has been correctly positioned, then we need to position the center so that the front stop rests lightly against the die-cut element.

After that the cardboard or die-cut is firmly pushed towards the mold.

Without moving the press from the mold-lowered position, the longitudinal adjustment of the mold contrasts is done. The ideal position is that in which there is a gap of 2 mm between the die-cut element and the mold contrast.

The regulation of the rear contrasts is exclusively to maintain the ideal distance of 2 mm between the press and the cardboard.

After regulating the forming mold corners, it is necessary to position the introducer devices. Manually the press is lowered.

The unit for doubling the end is supplied as an optional accessory and is therefore mounted later. It must be mounted as in the appropriate seat between the fixed profiles of hopper.

The unit for doubling the end is supplied as an optional accessory and is therefore mounted later. It must be mounted as shown in the figure in the appropriate seat between the fixed profiles of hopper.

The unit for doubling the side is supplied as an optional accessory and is therefore mounted later. It must be mounted as the appropriate seat between the fixed profiles of hopper. The regulation of the correct position concerns the height only, which is regulated using the special threaded regulation bar. The ideal height of the side double folding unit is when the start of the curve of the fixed check is at the same height as the crease of the side double fold.

After doing all kind of adjustments the main power is switched on and all the safety measures should be taken and these is how all the mechanism has been done and settled up for the production of consumer needed boxes.

Mechanism analysis shows that in the real field of work the machine operates in its correct way of operation but the cardboard suckers miss some of the cardboards from the loader panel.

3.4 Glue analysis

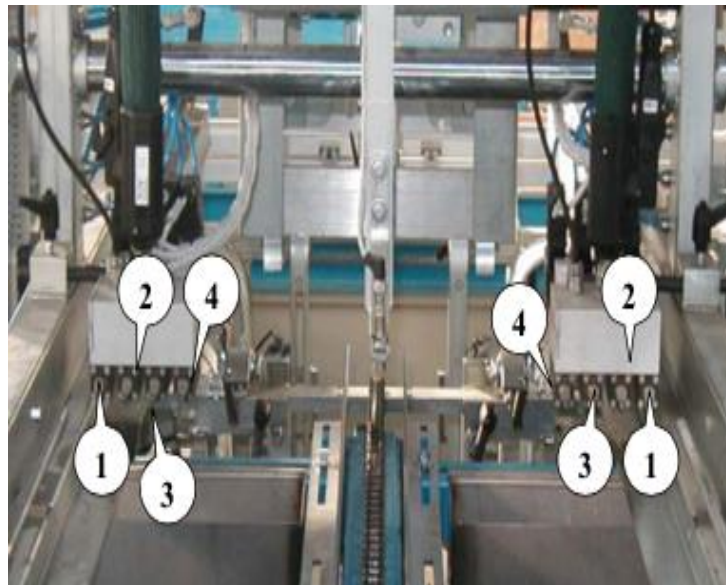
In the passage from the store to the pressing station, the die-cut element passes under 2 nozzle units, known as glue guns, which deliver hot melt glue following a set timing schedule which varies for every size of cardboard processed by the machine.



1. LH glue gun
2. Rh glue gun
3. Dragging belt
4. Running guide

Figure 15. Glue guns

There are four different types of glue application solenoids. Solenoids controlling glue application nozzles 1 and 2 on left side and right side. The control acts on both nozzles at the same time and envisages a maximum of 4 applicable gluing areas. Solenoids controlling glue application nozzles 3 and 4 on left side and right side. The control acts on both nozzles at the same time and envisages a maximum of four applicable gluing areas.



- 1. Nozzle 1
- 2. Nozzle 2
- 3. Nozzle 4
- 4. Nozzle 5

Figure 16. Glue nozzles

Starting with the initial die-cut element as shown in Figure17, an example is presented below for the programming of gluing for the production of a “platform” with an upper band.

The first operation is to identify the point reached by the flap on the sides and trace the positions of the 4 flaps.

After identifying the arrival point on the side, trace the positions of the gluing areas on the die-cut element (the number of gluing areas depends on the number of nozzles on the forming machine).



Figure 18. Glue programming

After analyzing all kind of gluing process is, it has been revealed that after following all kind of standard procedure of gluing the machine should perform its gluing procedure perfectly. But in the practical field, it is not.

3.5 Quality and output analysis

ABMM is manufactured to produce 40 boxes per minute. Which means 2400 boxes of products should be packed in one hour. That means in one working hour day (14 hours), the machine should be capable of producing 33600 boxes in one day. But with respect to the company demand the ABMM is not producing that much of boxes.

The table shows a number of differences between the standard production and current production.

After doing analysis on so many major part of the ABMM it clearly shows that some significant changes could be made if some major steps are taken.

The analysis process was so effective that some significant outcome has been found after the process was completed.

Table 6. Efficiency of the machine

Phase	Cases per minute	Efficiency	Summer production	Winter production
Original	40	99.90%	201600(per week)	18000(per week)
Current	25	41.6%	83865	7488

The analysis is done not only as a researcher but also as a operator of ABMM. It helped a lot to find out not only different figure of production numbers but also to find out the mechanical improvement for the automation process.

4 Conclusion

The total study process of the thesis work had gone through by following some methods and data sheets, which helped the researcher to introduce a new vision for the machine operating system, collect all the results of experiments and calculation.

4.1 Main findings of the research paper

The researcher's critical observation and study of ABMM gives a total documentation on how ABMM operates. It made possibility to detect the errors of the machine and the errors done by operators and the errors, which happens by the supplies to the machine.

Firstly, the study found out that, ABMM has a manual loader panel. The loader panel needed to be refilled in every 15 minutes. The refilling process makes delay the flow of production. The loader panel adjustment is also manual. Every time of refilling the operator have to come by himself to refill it.

Secondly, the sucker panel has also some defects. The rubber pads on the sucker nozzle are rarely changed and because of that the gripping power of those nozzles are not sufficient.

Thirdly, and the most important finding of the research found out that the die cut element which is used for ABMM is not always have the required measurements. STORA ENSO Company and Packages is the producer of the die-cut element.

The cardboard have a problem with its alignment to each other within the bundle. During the transportation the environment of the transportation affects the cardboards.

Moreover, the sucker nozzles cannot suck the cardboards properly. One of the reasons of this problem is the thickness of the cardboards. When the loader panel is only half filled then there is not enough pressure for the sucker to suck it.

The conveyor, which conveys the cardboard up to the mold, has also some defects. Originally the conveyor is programmed in that way that it has to take the cardboard all the way to the stopper but if there is a change of cardboard dimensions, then the sensors can not sense the small amount of dimension changes and for that reason the sensors do not stop the mold. As a result after mold press the boxes are stacked with the mold. It happens when the cardboard dimensions are bigger than needed. If the cardboard is smaller than original size then the mold positioning is not right and it cannot make the folds and bends.

The glue nozzles are sometimes spraying the glue quite widely. The reason is the glue nozzles get bigger because there is some time impurities in the melted glue and for the air pressure of the nozzle it comes out. But this problem is very rare.

Delivery panel of ABMM is not enough long. So After making two boxes the ABMM stops. Then the operator has to take the boxes out from the delivery conveyor and then the machine starts automatically again.

The printer heads are good enough to print visible texts but sometimes the text quality is very poor. Through out deep observations researcher found out that the material of the cardboard is not always same. For this reason the printing quality is not always same.

4.2 Evaluation and recommendations

For the better solution of the problems that came up by the study on ABMM maintaining so many factors did the research. One of the factors is costs for the improvements, then company demand and specialized work force. There was very good balance between reality of doing changes and thinking of better changes. At first the cost issue was very important because it has an important role on production cost. But some of the investments on improvement are long lasting improvements.

The recommendations are sorted in different segments.

1) Making a bigger loader panel that can carry more numbers of cardboards could decrease the loader panel issue of refilling. For this kind of change in the loader panel it is needed some technical knowledge on ABMM. The maintenance department of Famifarm Oy is skilled enough to do such changes.

2) The pads of the sucker nozzles should be changed in a regular basis because if the sucker nozzles are missing its gripping points then the cardboard is wrongly placed on the conveyor belt. If the loader panel is big enough to carry more cardboard in it then it will have more weight and the suckers could suck each cardboard perfectly.

3) The dimensions of the cardboard are very important factor to take concern of. Because of the dimension issues the whole process of box making is

affected seriously. Actual dimensions are very hard to get because there is transportation and weather issues. Acceptable dimension difference is 0.89%. But if all the cardboard has same size of then also it is possible to carry out the whole process but in one bundle of cardboard there are different dimension differences. The operator can easily make some changes in ABMM according to the dimensions. But we need to train the operators first. The producing company of cardboard should to be notified about these dimension factors.

4) The cardboard quality can be improved for the betterment of the production. The price difference is not high also. If a bit thicker and good quality of cardboards is purchased then it can show a significant improvement on the production. The price factor is not affecting the production cost in comparison of the wastage of the cardboards. If the wastage amount is getting lower and the production rate is growing higher then the production rate also comes down.

5) The glue guns should be cleaned in weekly basis. Then the gluing nozzles can spray out exact amount of glue. If the gluing area is not glued properly then the box is not usable anymore. For that reason a piece of cardboard and time is counted as wastage.

6) The delivery panel could be made a bit longer. The ABMM stops making boxes if the conveyor is full. To have a more production rate the conveyor of the delivery panel should to be changed.

7) The printing quality is also depending on the material quality of the cardboard. If the cardboard materials are of good quality then the text quality on it will be also visible significantly.

If these recommendations are accepted for ABMM then the production rate could be increased from 41.6% to 80%. This huge increment on production rate will seriously have an outstanding effect for company profit.

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Interview

Hannu Soininen, Famifarm Oy (2014)

Jani karkäinen, Famifarm Oy (2014)

Appendices

Appendix 1

Figure 1. Boxes on delivery conveyor





Figure 2. Cardboard stacked

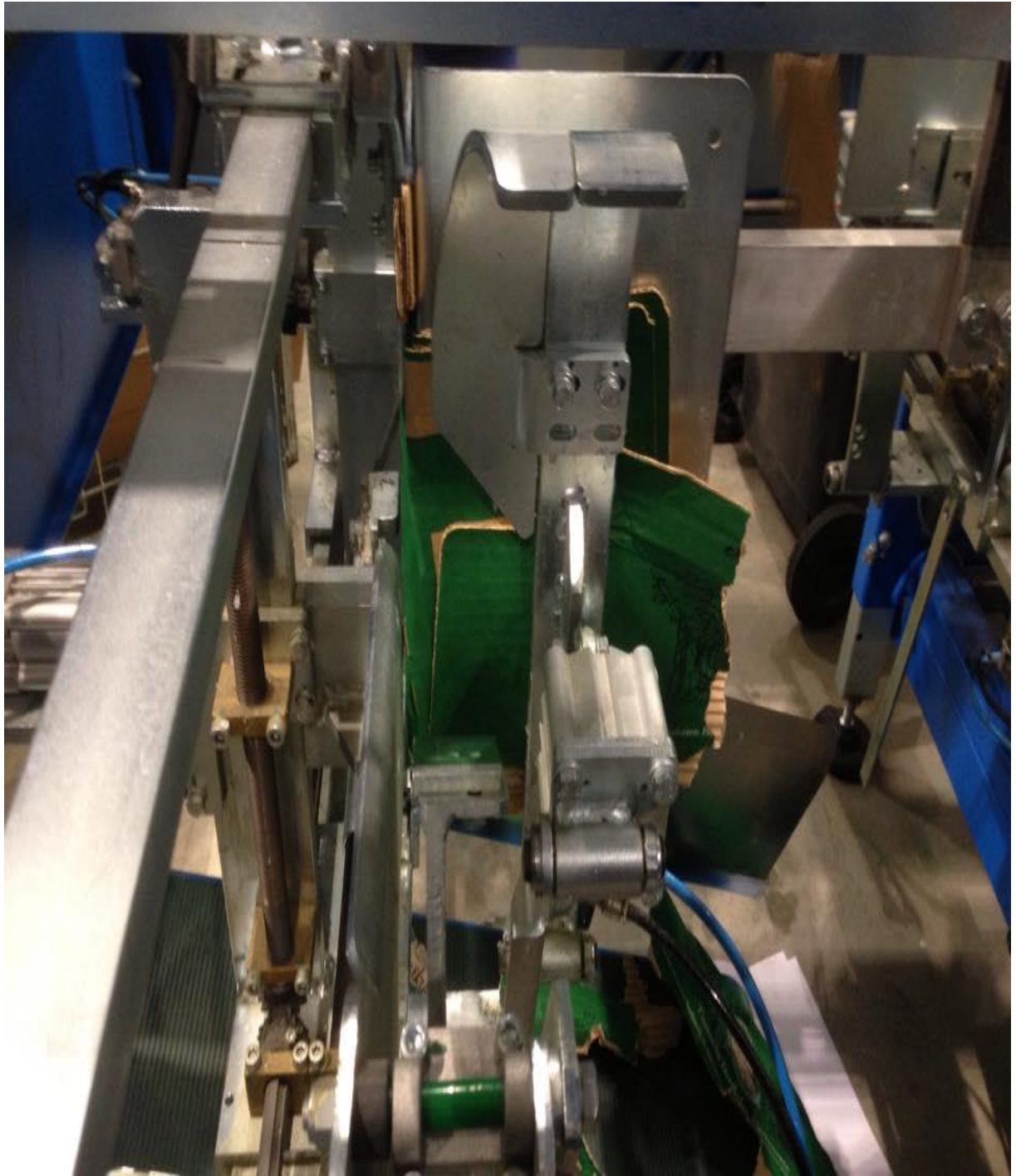


Figure 3. Wastage of cardboard



Figure 4. StoraEnso cardboards



Figure 5. Cardboard loading panel



Figure 6. Controlling device of ABMM



Figure 7. Caution Notice on ABMM

	<p style="text-align: center;">CAUTION</p> <p>All equipment, adjustment and maintenance operations must be carried out by qualified technical staff authorized and instructed to operate on the machine.</p>
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